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Title: Validity, reliability and clinical utility of the Disabilities of Arm, Shoulder and Hand Questionnaire in adults following stroke.

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Abstract

Purpose: The Disabilities of Arm, Shoulder and Hand (DASH) questionnaire is a patient reported outcome measure for evaluating upper limb function in people with musculoskeletal conditions. While the DASH has good psychometric properties when used with people with musculoskeletal conditions, it has not been tested with adults after stroke.

Methods: Data for n=61 adults following stroke (aged 32 to 93 years, 44% male) were included in the analyses. Data included demographic and clinical attributes, DASH scores (baseline and 4 weeks later) and Patient Rated Wrist Evaluation (PRWE) measures**.**

Results: Internal consistency was good (Cronbach alpha 0.92, SEM 6.65). Factor analysis and Rasch modelling suggested that the questionnaire comprised three subscales: pain, impact and function. Concurrent validity between the DASH and PRWE (Spearman's Rho r_s=0.41) was moderate. The scale was perceived by clinicians to be useful, quick and simple to administer. The DASH had low four-week test-retest reliability (ICC 0.56 [95% Cl 0.05-0.79).

Conclusion: The DASH is considered to have acceptable validity when used with adults following stroke. Test-retest reliability was low but further research is needed to establish whether this is a result of condition-related change or the stability of the measure.

Key Words: assessment, measurement, function, participation, psychometric

Introduction

Stroke is the third most common cause of death and the leading cause of adult disability in the Western world [1]. Upper limb motor impairment is highly prevalent and disabling, affecting 80% of adults after stroke [2,3]. Participation in upper limb rehabilitation therapy may improve function [4] hence, therapists dedicate a large proportion of therapy time to retraining upper limb movement and use.

The process of stroke rehabilitation commences with assessment and measurement of function [5]. There are a number of outcome measures that can be used to quantify upper limb function post stroke [6,7]. One of these is the Disabilities Arm, Shoulder and Hand (DASH) questionnaire [8]. Outcome measures need to be valid, reliable and clinically useful [9]. Although the DASH questionnaire is sometimes used with adults after stroke [10] there have been no investigations of its psychometric properties or clinical utility with this population.

The DASH is a 30 item self-report questionnaire, initially designed to assess patient rated upper limb impairment and impact on activity in individuals who have musculoskeletal upper limb conditions [8]. The total score is 100 and higher scores indicate greater disability. Psychometric examination of the DASH with musculoskeletal populations (arthritis, shoulder and elbow arthroplasty, Colles fracture, proximal humeral fracture and carpal tunnel syndrome) found it to be reliable [11-15], valid [16-19] and simple to administer[16,20-22]. Specifically, the DASH had good internal consistency (Cronbach's alpha=0.92-0.98) [11,14,15], and test retest reliability (Intraclass Correlation Coefficient=0.93-0.96) [11-13] in the tested populations. Construct validity when used in the musculoskeletal populations is good when compared to other upper limb outcome measurement tools such as Shoulder, Pain and Disability Index (r=0.70 to 0.88) [16,19], American Shoulder and Elbow Surgeons Standardised Shoulder Assessment (r=0.70 to 0.81) [16,17], and Brigham and Women's

Carpal Tunnel Questionnaire [17] (r=0.86). Convergent validity with the Patient Rated Wrist Evaluation (PRWE) was found to be significant in patients with a Colles fracture [18]. The DASH has also been found to be simple for therapists and patient participants to complete and score; the time taken to complete the DASH ranges from three minutes to 13 minutes [16,20-22].

DASH items have been proposed to have face validity, acceptable for measuring post-stroke upper limb impairment [23]. In addition, the DASH has an activity-based focus with items such as meal preparation and dressing. As upper limb rehabilitation programs are increasingly directed towards attainment of functional goals in every-day contexts, it is important to have standardised measures that can capture performance across impairment, activity and participation. A small number of studies have used the DASH as an outcome measure with adults after stroke[24,25]. Furthermore, researchers and clinicians working with people with stroke have identified the questionnaire as a potentially useful measurement tool [23]. However, to date, no published research has examined the applicability of the DASH post stroke. This study will provide information regarding the validity, reliability and clinical utility of the DASH in a post-stroke adult population. Specifically, information regarding internal consistency, concurrent validity and test retest reliability of the DASH will be investigated

Method

Design: This study evaluated psychometric properties of the DASH using previously collected data from three published research studies [10,26,27]. Data were extracted for post-stroke adult-participants and the DASH was examined for internal consistency, concurrent validity, test-retest reliability and ease of administration.

Sample: All participants were adults following stroke. They were participants in one of three studies recruited from acute, sub-acute and rehabilitation facilities between October 2002 and November 2006. The three studies used consistent eligibility criteria: 18 years or over, able to give informed consent with a history of a single stroke that resulted in weakness or paralysis of the upper limb. They could understand English. Patients were excluded if they had a Mini Mental State Exam score (MMSE) of less than 24 out of 30 [28,29]. Please refer to Figure 1 below for a breakdown of sample participants and the data used for psychometric testing.

Insert figure 1 about here

Instruments: A researcher-designed data extraction form was used to collate data and enter it into Statistical Package for Social Science Version 21.0 (SPSS) [30] for analysis. Demographic variables were age, gender and level of education. Clinical characteristics were hand dominance, the number of days post-stroke when the DASH baseline measure was administered, MMSE Score, UL-MAS score, upper limb function scores were DASH and the PRWE.

The MMSE [28] is a standardised cognitive assessment tool. The MMSE is routinely used in acute and longer term rehabilitation settings to monitor cognitive function in adults after stroke [28,31]. The UL-MAS [32,33] is one component of the Motor Assessment Scale and involves assessment of simple functional tasks performed by the upper limb. It has good psychometric evidence in post stroke populations [32]. The PRWE [34] is a 15 item patient self report questionnaire, published in 1996 and designed to assess the pain and function of individuals experiencing a musculoskeletal wrist condition [34]. It has psychometric evidence demonstrating good reliability and validity [35,36] and convergent validity with the DASH in musculoskeletal populations [18].

Data analysis: Data were analysed using SPSS [30] and the Winsteps program [37]. Demographic and clinical data were analysed using descriptive statistics. Scale characteristics were examined as follows.

Internal Consistency was examined using both traditional test statistics and Rasch approaches. Cronbach's alpha [38] was calculated to indicate the internal consistency reliability of DASH items; alpha ≥0.95 was considered desirable for clinical use [39]. Standard error of measurement (SEM) was also calculated by applying the Cronbach's alpha score and standard deviation to Nunnally and Bernstein's (1996) SEM formula. This provides an indication of internal consistency independent of the population measured [40]. The fit of items and people was also examined post-hoc using Rasch analysis. Rasch analysis is a means of converting ordinal data to interval data and creating a hierarchy; these fit statistics allow examination of the proportion of people whose data meet the Rasch assumption that people with greater arm movement (less disability) will be more likely to receive lower DASH item subscale scores. The unidimensionality of the DASH items were examined through goodness-of-fit statistics generated by the Rasch analysis. These fit statistics indicate how well the items in the DASH conformed to the assumptions of the Rasch model; infit statistics describe the fit of items near the middle of the scale, and outfit statistics describe the fit of items near the extremes of the scale. The desired values of the mean square and t statistic are 1 and 0, respectively. For this study, mean square values of 0.6 to 1.4 were considered acceptable, with a t statistic of ±2, because these correspond with 95% fit [40]. In the present study, those items that did not fit were investigated to determine whether they shared any common characteristics.

Concurrent validity was examined using Spearman's Rho (due to the ordinal nature of the data) to determine the strength of correlation between the two tools [41]; between 0.0 and 0.30 indicates weak evidence for validity, 0.30-0.59 indicates moderate evidence and a score of 0.59 or above indicates strong evidence for validity [42]. The total DASH and PRWE scores were compared, as well as the pain severity and functional subscale scores.

Test retest reliability was measured using the Intraclass Correlation Coefficient (ICC) [43]. If the correlations were above 0.90, reliability was excellent and low test retest reliability if the ICC was below 0.70 [44]. Item total correlation was also conducted to determine whether the DASH questionnaire was able to discriminate between high and low performing participants [44]. Pearson's correlation coefficient was used to measure the item total correlation. Research suggests that a Pearson's correlation coefficient score > 0.30 indicates that the item is discriminating between high and low performing participants [44-46].

Ease of administration was calculated using descriptive statistics to summarise responses to questions regarding time taken to administer, and ease of use and scoring for the DASH.

Results

Table 1 presents demographic and clinical data from the sample, divided into two groups. Both groups were statistically similar for all demographic variables. Sample B had more people with dense hemiplegia compared to sample A as measured by MAS (81% vs 67%).

Insert table 1 about here

Internal consistency: The DASH was found to have good internal consistency (Cronbach alpha=0.92, SEM=6.65). An initial calibration of the DASH items identified a violation of the unidimensionality assumption. To examine the factor structure of the items in this population, an exploratory factor analysis was conducted using polychoric correlations and unweighted least squares estimation [47]. This analysis identified three factors in the data (21 DASH items measuring function, six DASH items measuring pain, and three DASH items measuring impact). Separate calibrations for these three factors were conducted. Examined were person and item separation, item fit to the Rasch model, and residual principal component analysis (PCA). The quality of the measurement was assessed using the following criteria: separation greater than 2.00

(reliability=0.80) [40]; infit mean square for these rating scale items >0.70 and <.1.40 [40]; and for evidence of unidimensionality, more than 60% of variance explained by the measure and an eigenvalue <3 for the contrasts [48]. When all 30 items were calibrated, the measure explained 43.3% of the observed variance and the eigenvalue for the first contrast (function versus pain/impact items) was 5.4. When calibrated separately, the evidence of unidimensionality was better but in each case the percent of variance explained was lower than desired (ranging from 44.0 to 49.6). For the separate calibrations, the eigenvalues for the first contrast were acceptable (ranging from 1.7 to 2.3) suggesting no additional dimensions in the data.

When data for all 30 items were calibrated, little misfit was detected. One item (symptom: weakness in arm, shoulder or hand) had an infit mean square of 1.45, slightly exceeding the desired criterion. When the function items were calibrated separately, another item (sexual activities) misfit (infit MnSq=1.53) but no misfit was found in the separate calibrations for the pain and impact items. However, the separate pain and impact scales showed little ability to differentiate between high and low scorers. The person separation index was 1.25 (reliability=0.61) for the pain items and was 0.79 (reliability=0.38) for the impact items. In an attempt to improve upon these results, the pain and impact items were combined and calibrated together so that the scale consisted of two dimensions, which were ‘function’ and ‘pain/impact’. In this calibration, the measures explained 48.3% of the variance, the eigenvalue for the first contrast was 2.6 with pain items loading positively and impact items loading negatively. There were no misfitting items and the person separation was better (1.50/.69) although only barely acceptable.

These results suggest that category collapsing is needed to reflect the response patterns within this population; there are at least two dimensions in the items (function and pain/impact); there is little evidence of misfit when all items are calibrated together but some occur when the construct is more narrowly defined; and the ability of the function items to distinguish multiple levels of these traits in this population is good (at least 3 levels discernible) but the pain and impact items cannot distinguish two levels.

Insert figure 2 about here

Concurrent Validity: Correlation between the total scores was r_s=0.41 (p=0.023). Figure 2 demonstrates the moderate total score correlation. Although data plots are widely scattered, overall a higher score on the DASH was reflected by a higher score on the PRWE. Subscale concurrent validity was also moderate. The highest correlation was between the pain severity scales with a retest of r_s=0.53 (p=0.003). The functional subscales had a result of r_s=0.51 (p=0.003). Finally, the correlation between the total scores was r_s=0.41 (Spearman's rho) (p=0.023).

Insert figure 3 about here

Reliability: The mean change score in this participant group was -0.36 points on the DASH, with the mean score for baseline equaling 58.93 and the mean score 4 weeks after equaling 58.57. Results indicated that the DASH had low test retest reliability (ICC=0.56 [95% CI 0.05-0.79]) when tested on a second occasion four weeks later [44], even though participants' functional movement did not alter during this time as measured using the Motor Assessment Scale (UL-MAS). A review of the item total correlations was completed; results ranged from 0.18 to 0.77, suggesting that not all DASH items discriminated between high and low performing participants [44]. The two items that fell below the 0.3 mark were question 26 "*tingling (pins and needles) in your arm, shoulder or hand*" (r=0.18) and question 30 "*I feel less capable, less confident or less useful because of my arm, shoulder or hand problem*" (r=0.29).

Ease of use: The DASH and PRWE demonstrated similar results, with both assessment tools considered adequate for application in clinical settings. Results can be found in Table 2.

Insert table 2 about here

Discussion

This study evaluated the psychometric properties of the DASH when used with adults after stroke and is the first study to our knowledge to conduct this type of evaluation. Previous studies have reported the DASH is a psychometrically sound tool for use with musculoskeletal conditions [19]. The present study provided unique information on the validity, reliability and ease of use of the DASH when used in a post stroke population.

The DASH aligns well with a focus on upper limb function and associated impact on activity. We found it to be quick and simple to administer with adults after stroke. Our analyses showed there was good internal consistency for the measured sample [38]. Previous studies conducted on the internal consistency of the DASH also delivered good to excellent Cronbach alpha scores for a range of musculoskeletal conditions [11,15], and our findings in a population of adults after stroke concur with this. However, the questionnaire appears to have subscales. It was evident from Rasch modeling and factor analysis that the dimensionality across items differed; that is, the DASH is most likely behaving as three separate scales (functional use, pain, and impact). Clinicians should interpret the findings of the DASH not by total score alone but by examining each response and considering these in relation to the three identified themes.

The concurrent validity of the DASH with the PRWE was moderate, indicating that the tools potentially measure different constructs. The PRWE was chosen for this study as it includes features of functional hand and wrist use and symptoms [44]. However, both tools were designed for use with musculoskeletal populations and so the results of this analysis should be interpreted with caution. The moderate correlation suggests that both tools are measuring upper limb function and impact on activity in a meaningful but potentially different way. Our findings were not as strong as those from a previous study [18], where the DASH and PRWE were found to correlate well in the musculoskeletal population [18]. In comparing our results with the broader literature, it is possible that adults post stroke could respond differently to the DASH questions compared to people with a musculoskeletal condition. The moderate validity result did support the operationally defined theories of the tools, with the DASH purporting to measure function and symptoms in the upper limb as a whole [8], and the PRWE purporting to measure function and pain in the wrist only [34].

Our study also investigated test-retest reliability of the DASH; within this sample of people with dense hemiplegia the DASH did not perform well [44]. These findings differ from previous results in patients with musculoskeletal conductions, which identified the DASH as having excellent test retest reliability [11,12]. This difference may be related to the nature of stroke, which is sudden in onset and our population who were on average six weeks post stroke. A further limitation of our study is that the DASH is a self-report tool. Self-report tools may be susceptible to the effects of bias due to ‘response shift’, which occurs when people’s views, values or expectations change over time and do not correlate with objectively measured change [49]. In addition, patients may have gained more insight into their deficits over time; for example at the time of first assessment patients’ might have had a limited understanding as to how their upper limb physical dysfunction would impact on tasks asked in the DASH because they had limited opportunity to practice those tasks. The poor test-retest reliability may also be a function of our sample who had moderate to severe upper limb impairment.

Although this is one of the first published studies investigating the use of DASH with stroke survivors, we caution the generalisability of our findings at this time. Our sample was over-representative of stroke survivors’ with dense hemiplegia, that is, unable to move their hemiplegic upper limb. Our findings suggest that scale dimensionality is not consistent across the DASH, and that for stroke survivors category collapsing is needed to reflect the response patterns within this population. We therefore recommend further testing of the DASH on a larger sample size and that future studies should investigate category response.

Conclusion

The DASH questionnaire appears to be a clinically useful measure for adults following stroke. Further research is required to establish scale response and test-retest reliability as poor outcomes in this study may have been the result of moderating factors, including low levels of upper limb movement and emerging acceptance of upper limb disability in the test re-test period. The importance of understanding functional disability from the perspective of the patient, as well as the ease in which clinicians found the DASH to administer, makes further investigation warranted.

Implications for Rehabilitation

- The DASH questionnaire examines upper limb function in task performance and appears to be a useful tool which is simple to administer in the clinical setting with adults following stroke.
- Upper limb function post stroke can be meaningfully assessed using the DASH as it has good internal consistency and moderate concurrent validity.
- Rasch analysis and factor analysis suggests that the tool appears to consist of three subscales: pain, impact and function. The total score of the DASH may be less meaningful than the totals of these subscales.
- The test-retest reliability of the DASH requires further research; over a four week period DASH stability was poor in a group of people with moderate to severe upper limb impairment.

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Table 1 Sample Demographic Characteristics

Characteristic	Sample A n=61*	Sample B n=32
Age in yrs, M SD	68.6 SD 14.5	72.1 SD 12.4
Gender, n (%)		
Male	27 (44.3%)	16 (50%)
Post stroke, days M SD	43.1 SD 69.8*	27.9 SD 14.4
Dominant Hand, n (%)		
Right	48 (78.7%)*	31 (96.9%)
Affected Side, n (%)		
Right	17 (27.9%)*	11 (34.4%)
Education, in yrs M SD	10.5 SD 3.4*	10.4 SD 3.6
MMSE, M SD	24.7 SD 3.6*	23.7 SD 3.6
UL-MAS 6, M SD,	0.7 SD 1.3*	0.2 SD 0.4
Median (Range)	*0 (0-6)**	*0 (0-1)*
UL-MAS 7, M SD,	0.7 SD 1.5*	0.0 SD 0.0
Median (Range)	*0 (0-5)**	*0 (0-0)*
UL-MAS 8, M SD,	0.3 SD 0.9*	0.0 SD 0.0
Median (Range)	*0 (0-4)**	*0 (0-0)*

Note: Sample A: includes data from the DASH questionnaire only. Sample B; includes data from the DASH and PRWE at baseline and 4 weeks later. M: Mean, SD: Standard Deviation, MMSE: UL-MAS
* demographics calculated on a reduced sample of n=51 due to missing data

Table 2 Ease of Use of the DASH

Variables	DASH	PRWE
Time Taken, in mins, M SD	08:45 SD 04:14	04:36 SD 03:21
Prompts Required, M SD	13.5 SD 19.4	8.8 SD 11.3
Method, n (%)		
0=Self Administered	9 (10.5%)	6 (7.0)
1=Examiner read out, subject circled response	1 (1.2%)	3 (3.5 %)
2=Examiner read, subject stated response	45 (52.3 %)	48 (55.8%)
3=Examiner read out, subject pointed to the response	2 (2.3 %)	2 (2.3%)
4=Examiner read out, subject pointed to response on enlarged scale.	4 (4.7%)	5 (5.8%)
5=Other	12 (14.0%)	10 (11.6 %)

Note: M:Mean, SD: Standard Deviation

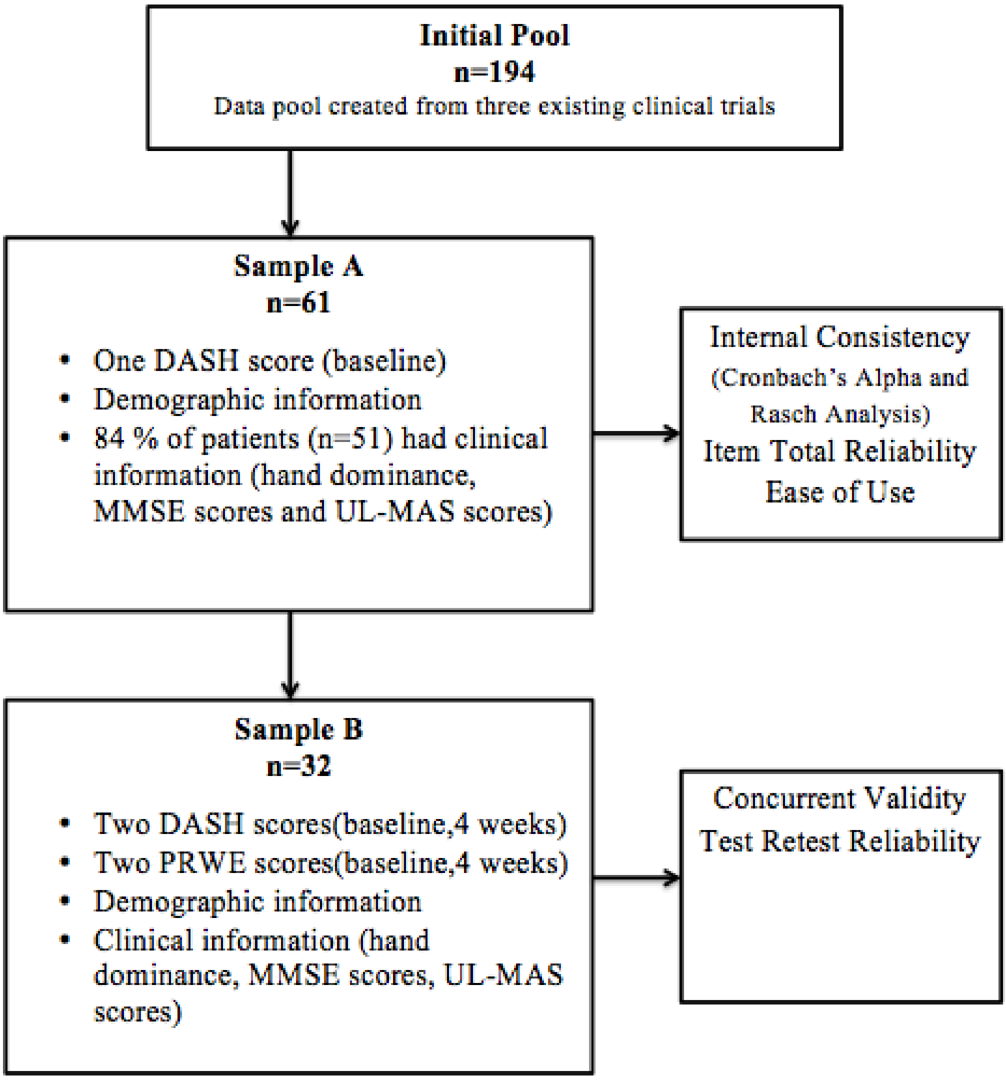

Figure 1. Flow chart of included sample

Item Fit Map

```
       Persons MAP OF Items
                 <more>|<rare>
  70                  .  +
  69                  .  +
  68                     +
  67                  .  +
  66                  #  +
  65                    T+
  64                  #  +
  63                  .  +  Tingling (pins and needles) in your arm, shoulder or hand.
  62                 ##  +
  61                  #  +  During the past week, how much difficulty have you had sleeping because of the pain
                           in your arm, sh
  60                  .  +T
  59               .### S+
  58            #######  +
  57               .###  +
  56                ###  +  Turn a key
  55             ######  +S Arm, shoulder or hand pain.
  54             .#####  +  Arm, shoulder or hand pain when you performed any specific activity
                            Stiffness in your arm, shoulder or hand.
                            Write
  53            ####### M+  Place an object on a shelf above your head
                            Wash or blow dry your hair
  52               .###  +  Carry a shopping bag or briefcase
                            During the past week, to what extent has your arm, shoulder or hand problem
                           interfered with your no
                            Push open a heavy door
  51              .####  +  Put on a pullover sweater
                            Sexual activities
  50               .###  +M Manage transportation needs
  49             .#####  +  Recreational activities which require little effort
                            Use a knife to cut food
  48               ####  +  During the past week, were you limited in your work or other regular daily
                           activities as a result o
                            Prepare a meal
                            Weakness in your arm, shoulder or hand.
  47              .#### S+  Wash your back
  46                .##  +  Make a bed
                            Open a tight or new jar
  45                 .#  +S Carry a heavy object (over 10 lbs)
                            I feel less capable, less confident or less useful because of my arm, shoulder or
                           hand problem.
  44                  .  +  Do heavy household chores (e.g., wash walls, wash floors)
                            Garden or do yard work
                            Recreational activities in which you move your arm freely
  43                 ##  +  Change a lightbulb overhead
                            Recreational activities in which you take some force or impact through your arm,
                           shoulder or hand
  42                 .#  +
  41                  . T+
  40                     +T
  39                  #  +
  38                  .  +
                 <less>|<frequ>
 EACH '#' IS 2.
```

Figure 2. Item fit map comparing the hierarchy of the original 30 items

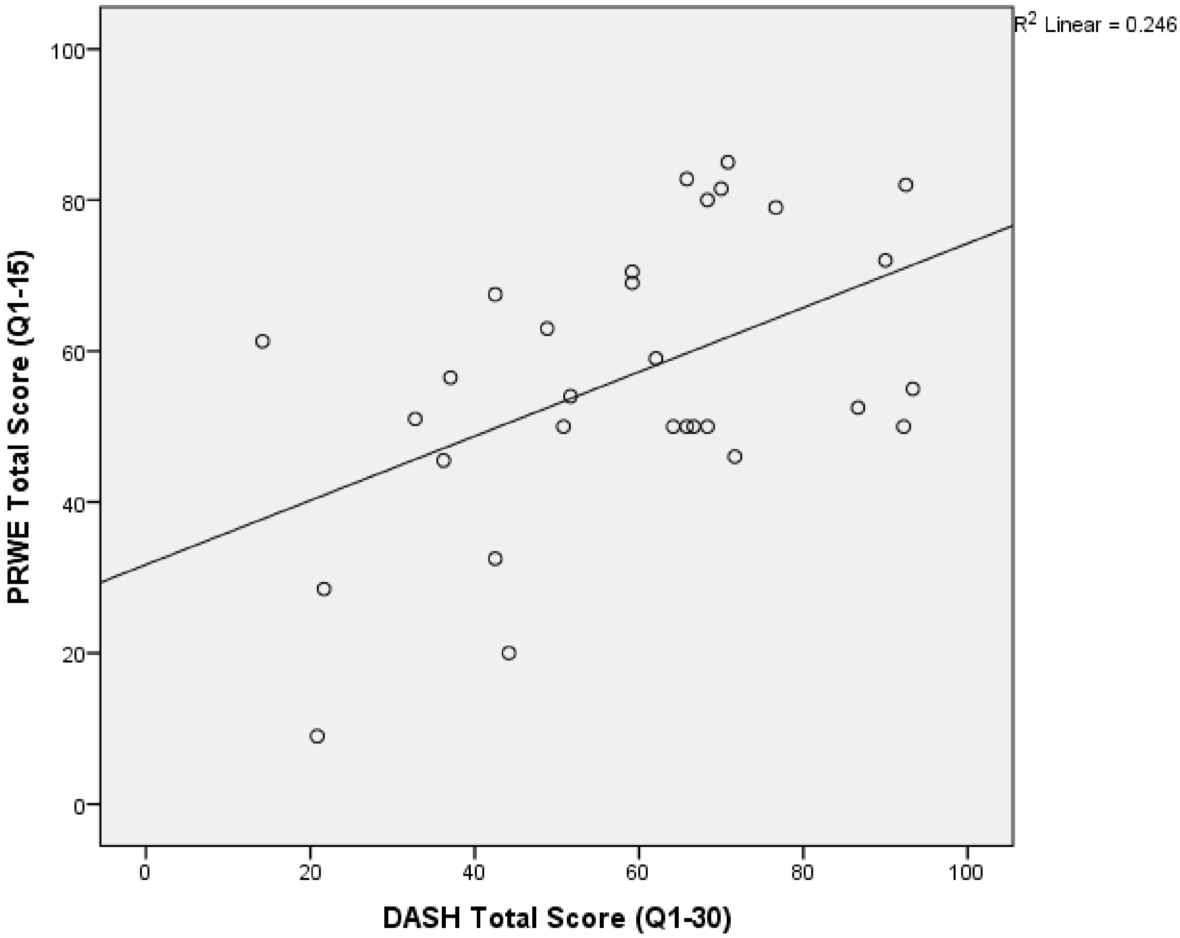

Figure 3. Scatter Plot of total DASH and Patient Rated Wrist Evaluation scores